LATENT-IMAGE PROJECTION SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

This invention relates generally to the creation and display of entertaining visual images and, more particularly, to the production and display of visual effects and optical illusions by projecting a polarization-encoded latent image onto a viewing screen.

A known video image projection system, shown in FIG. 1, and generally referred to by the reference numeral **10**, contains a projector **12** that projects a video image onto a viewing screen **14**. The projector includes a light source **16**, a pre-polarizer **18**, a transmissive-type liquid crystal (LC) matrix **20**, an analyzer **22**, and a projection lens **24**. The light source uniformly illuminates an image area on the LC matrix with substantially parallel light rays. The pre-polarizer polarizes the light to have a single linear polarization direction before it reaches the LC matrix. The LC matrix includes an array of pixels that rotate the polarization of light passing through each of the pixels in response to an electric field applied to each pixel. To polarization encode the light with the video image, the LC matrix modulates the electric field applied to each pixel in response to a video signal.

The analyzer **22** is a second polarizer having its linear polarization direction oriented perpendicular to the polarization direction of the pre-polarizer **18** so that only the light having its polarization direction rotated by the LC matrix **20** passes through the analyzer. In some instances the analyzer is integral with the screen **14**, but normally the analyzer is located between the LC matrix and the projection lens **24**. After the polarization-encoded light passes through the analyzer, the projection lens projects the image onto the screen. The screen typically has a diffusely reflective coating **26** that allows viewing of a projected image by the unaided eye across a wide viewing angle.

In the video image projection system **10** described above, the video image is analyzed before it is diffusely reflected by the screen **14**, and a visible image is readily perceived by the unaided eye merely by viewing the screen. Thus, the system's ability to produce entertaining visual effects generally is limited to those effects that have a viewer directly view the screen with the unaided eye.

Another known system displays alphanumeric messages for viewing only by selected viewers. The display includes an LC matrix illuminated from the rear by polarized light. The LC matrix rotates the polarization direction of the light to polarization encode the alphanumeric message. Only selected viewers are able to distinguish the alphanumeric images by viewing the LC matrix though polarized glasses. Other viewers, not wearing polarized glasses, will not see the alphanumeric images when viewing the LC matrix directly and instead will perceive a uniformly illuminated area. Since the cost of an LC matrix increases greatly with its size, the cost of producing a display using a direct view LC matrix for a large projection screen would be quite expensive. Also, the positioning of the display is limited by the need for an electrical connection to drive the display's LC matrix. Thus, displays that use a direct view LC matrix are limited in size and versatility.

Accordingly, there is a need for an imaging system that economically provides a polarization-encoded latent image on a relatively large screen for viewing by a large or selected audience using an analyzer. Also, there is a need for a latent-image display system that has a screen that can be located in an environment inconvenient or hostile to electrical components. The present invention satisfies this need.

SUMMARY OF THE INVENTION

The present invention is embodied in a latent-image projection system, and related method, for projecting a polarization-encoded image onto a polarization-preserving viewing screen that may be viewed by a selected audience using a polarizing analyzer. The image is latent in that it cannot be perceived except by viewers using the analyzer. The latent-image projection system provides a versatile viewing screen that can be conveniently sized and located as desired to create novel and entertaining visual special effects and optical illusions.

The latent-image projection system includes a latent-image projector, a polarization-preserving viewing screen, and an analyzer. The viewing screen diffusely reflects incident light without changing the light's polarization. The latent-image projector projects onto the screen a polarization-encoded latent image that is imperceptible to a viewer who directly views the screen. The light associated with the latent image has a predetermined polarization orientation. An analyzer, having a preferential polarization orientation that is aligned with the predetermined polarization orientation associated with the latent image, is located between the screen and one or more selected viewers so that a selected viewer, who uses the analyzer to view the screen, may perceive the latent image.

More particularly, the latent-image projector produces the latent image by directing light having a predetermined illumination pattern through an image area. The projector then alters the light's polarization orientation as it passes through the image area at predetermined locations throughout the image area without perceptibly altering the light's intensity at the predetermined locations. The projector then projects the polarization-encoded light passing through the image area onto the screen. The projector thus creates a latent image so that only the predetermined illumination pattern, and not the latent image, is perceived by viewers who directly view the screen and so that the latent image is perceived by the selected viewer who views the screen using the analyzer. The predetermined illumination pattern typically has a uniform light intensity so that viewers who directly view the screen see only a uniformly illuminated screen, while the selected viewer, who views the screen using the analyzer, sees the latent image.

In a more detailed feature of the invention, the latent image projector includes a light source, a pre-polarizer, a polarization rotator, and a projection lens. The light source uniformly illuminates the image area with a substantially parallel beam of light and the pre-polarizer polarizes the light from the light source to a first polarization orientation before the light illuminates the image area. The polarization rotator may be a transmissive-type liquid crystal matrix located in the image area. The matrix typically has a pixel array that defines the predetermined locations of the image area. The liquid crystal matrix rotates the polarization direction of the light at the predetermined locations in response to an electrical signal received from a video source as the light passes through the liquid crystal matrix to create the polarization-encoded latent image. Alternatively, the polarization rotator may be a transparent isotropic substrate having on one of its surfaces an anisotropic medium that rotates the polarization direction of the light at the predetermined locations as the light passes through the substrate. Typically, the anisotropic medium is a transparent half-wave retarding material that rotates the light's polarization orientation by 90 degrees and the preferential polarization orientation of the analyzer is oriented orthogonal to the polariza-